Besides the difference in general features above considered, there are others, notably the presence in the Melbourne sketch of a pair of bright wings at the N. extremity of the lemniscate, which are not indicated in the Cape drawing; this, however, and other differences of detail are in the direction to be accounted for by difference of aperture used, no certain conclusion can therefore be yet drawn therefrom.

ART. IV.—*Decay of Gaspipes in certain Soils.*

By G. FOORD, ESQ.

[Read 14th February, 1870.]

In September, 1867, it became the duty of the writer of this note to inquire into the cause of the decay of a gas-main, the property of the city of Melbourne Gas Company. The scope of the question submitted did not, at that date, extend beyond its purely commercial sense; but as there appears good reason for regarding the particular case as typical, and significant in reference to the broad subject of the "life" of gas and water mains, and because the subject has a scientific interest quite apart from its purely economic sense, I venture to lay before your Society such results as happen to be at this date at my command. In doing this, I wish to state that the particulars which I have to communicate are slight and imperfect; that no pretentions to a close investigation are set up; and that I should not have risked the presentation, for registration, of so imperfect an account of a fact of confessedly great intrinsic interest, if I had not been encouraged by your President with the assurance that your Society is always ready and anxious to receive and record matters of fact and scientific interest, even though the observations may happen to be of a disjointed and casual character. I confess a personal concurrence in those views, for in our new continent, over the expanse of which promising objects, inviting observation, are so abundant, but in which the number of precise observers are, relatively to the field of inquiry, so few, doubtless for some time to come, observation, as distinguished from methodical research and experiment, must take the lead; and the record of casual observations, even when unsupported by any extent of continuous inquiry or systematic experiment, must prove ultimately valuable. It is this conviction, coupled with the personal assurance of your President, which tempts me to present to your Society as a "laboratory note" what would otherwise remain in its place among the daily memoranda of laboratory work.

The facts of the case are the following:—Close to the site of the Melbourne old Exhibition building it has been found that the gas-mains are subject to an unusually rapid decay. The ground in which this quick decay occurs is at a high level (no less than one hundred feet above high-water mark in Hobson's Bay). It is one of the highest points in the city; the position, in fact, affords an excellent panoramic view of Melbourne. It would, therefore, appear to be favourably situated for drainage by percolation through the porous soil. The pipes, the subject of this note, are laid eighteen inches below the surface, in a nearly white mottled clay, which to mere inspection shows no external evidence suggestive of any constituents favourable to a rapid destruction of the pipes.

The sample of decayed pipe as received by me presented the following characters:—In some places it had entirely lost its metallic properties; it had passed out of the metallic state, but had retained its original form. In other places, an inner shell of unconverted cast iron remained. In one of the samples, which I submit, the converted portion is indicated by the mark *A*, and the unchanged part by the mark *B*. Sample *C* is wholly converted. *D* shows that the wrought-iron plugs are almost or quite exempt from the change. *E* is a sample of the substance of the converted pipe reduced to powder in a mortar; an impalpable odorous brown powder.

It may be here pointed out that the continuity of the changed parts, the continuity of the unchanged metallic portions, and the unchanged conditions of the wrought-iron plugs, are facts suggestive of a gradual conversion of the cast iron, progressive in space, and that the conversion proceeds under a galvanic agency, in which the graphite of the cast iron probably plays the part of the electro-negative element in a simple circuit of two solids and one fluid. The decay takes place from without inwardly.

The specific gravities of the decayed and unaltered or slightly altered portions of the pipe, are significant.

The specific gravity of the sounder portions of the pipe was ascertained to be	5·99
That of the decayed or converted portion	2·57
A sample with thin inner shell of metallic iron ...	2·88
Gray cast iron (for comparison) being	7·1

The decayed portion had lost to some extent, but not altogether, its magnetic properties. It is easily reduced to a greenish-brown powder, approaching the tint of raw umber. On solution in hydrochloric acid, it evolves no hydrogen—a fact which shows that it contains no residue of iron in the metallic state; when thus dissolved it leaves a bulky residue of graphite with silicon—carbon—and sulphur—compounds of iron and manganese.

The converted portion of the pipe, when newly taken from the ground, is soft, but hardens on exposure. During this induration shrinkage takes place, the converted portion separates from the unconverted, and cracks appear in the mass.

But another interesting manifestation takes place when the pipe is exposed to the air; after it has lost the greater part of its free-moisture, droplets of a solution of protochloride of iron are extruded from its pores. The drops of pale green fluid soon become covered with a rust-red film of hydrated sesquioxide of iron; the little fluid drops soon disappear by evaporation, leaving hollow shells of iron oxide, with possibly some oxychloride. It is pretty clear that in the fluid forming these drops the chlorine of the chloride of iron acts chemically as a "carrier," and is conducive to the ultimate conversion of the iron to the state of oxide; it is also clear that the chlorine, by combining with the iron and forming a soluble salt with it, enables the water to remove the metal through sensible distances of space. In pseudomorphic changes of the kind considered, this purely mechanical transposition of the materials is always an essential part of the process of the rebuilding, in new chemical forms, of the old materials.

The general composition of the altered portion of the pipe is shown by the following figures:—The powdered material gives off over 13 per cent. of moisture when heated, and it leaves as undissolved residue 28 per cent. of its original weight when digested in hydrochloric acid. The iron solution obtained by thus treating it contains protochloride of iron equal to oxide and chloride of iron in the decayed pipe to the extent of a little over half its weight.

How far these contents of the altered pipe account for all or only a portion of the original constituents of the metallic cast iron, or what proportion of the metal is removed in solution, I have not ascertained; the low specific gravity of the altered portion would imply either removal or expansion, probably both have taken place.

Water boiled with the powdered material of the pipe showed evidence of both sodium and chlorine abundantly present in solution—in fact, it is to the presence of common salt with concomitant agencies that the rapid transmutation of the cast-iron main may be attributed.

When the clay in which the pipe was imbedded is examined two points become conspicuously apparent—1st. The clay, retentive of moisture, is also so harsh and porous as to be permeable to air. In this sense it is the very opposite of "fat," water-tight, and consequently air-excluding clays. A block of this clay air-dried, when placed in water, rapidly falls, crumbling away in a surprising manner, at the same time releasing much air, and forming a gruel-like magma at the bottom of the water. A pipe of cast iron laid in this clay is, on account of the properties just mentioned, subject to the continuous and joint action of moisture and atmospheric gases. 2nd. But this clay has also another characteristic, it is charged with common salt. If we place it on a filter, wash it with distilled water, and evaporate the filtrate, a crop of cubic crystals of common salt is obtained. Results of experiments indicate 13 ounces of common salt per cubic yard of clay; the actual contents may somewhat exceed this proportion, for it is well known that clayey matters will obstinately keep in quasi-mechanical adhesion substances which would be, excepting for the presence of the clay, easily removed in solution in water.

That an alkaline chloride will promote the rusting of iron is instanced in the common iron-rust cement of the machinist. A dense network of iron turnings, moistened with solution of salammoniac, conforms to all the requisite conditions—permeability to air, the simultaneous presence of moisture, and a suitable soluble alkaline chloride, provided as an oxygen carrier.

In the case described we have almost identical conditions, with one exception. Our alkaline chloride is the chloride of a fixed, and not of the volatile alkali; we have chloride of sodium instead of chloride of ammonium, and it is not so easy to see how the chlorine forsakes its most intimate relations with the sodium to take up with the iron. The writer cannot pretend to anything approaching a discussion of this question on the basis of facts now presented. The subject is certainly a matter of great interest, which has not yet been fully discussed, and on which methodical experiment might be profitably expended. At present the writer contents himself with mentioning that, apart from the influence of voltaic decomposition, in which the graphite, iron and brine form the circle, there are conditions which are admittedly sufficient for bringing about the change, by enlisting only the simplest chemical means. Solutions of bi-carbonate of ammonium and chloride of sodium produce by interchange bi-carbonate of sodium and chloride of ammonium. This decomposition formed the subject of a remarkable invention patented about 30 years since by Hemming and Dyer. On it was based the process of the British Alkali Company; and although it did not succeed in an economic direction, the chemical change itself can be easily demonstrated by experiment, on the small or large scale, as an indisputable chemical fact. In the soil and porous clays we have a supply of both ammonia and carbonic acid, so that there is nothing wanting for bringing about a change of the kind considered. Moreover, the cast iron is permeable to gases, and the contained coal gas, although holding but little carbonic acid gas, is at all times a source of ammonia available for the chemical decomposition in point. The French chemists, investigating on behalf of agriculture, have also shown how, by means quite distinct from those just mentioned, common salt in a soil may be dissociated so as to yield sodium salts of an organic acid. In advancing these statements it is desired that the object be understood as that of showing that the conditions for possible chemical changes of the requisite kind do exist, and it is also wished that it should be understood that no assertion is advanced favouring any particular course of chemical exchange as *that which actually takes place,* of putting forward any agencies as *those certainly concerned* in such changes.

We know quite well that a conversion of cast iron, very similar to the one under notice, takes place in the sea, and iron pipes or pumps drawing salt water from mines have been found to decay from a similar cause. There is the case of a pipe in a coal mine, quoted by Dr. Henry. The specific gravity of the decayed pipe was 2·08 to 2·155, and the water of the mine contained of saline matter, chloride of sodium, chloride of magnesium, chloride of calcium, sulphate of lime, and bi-carbonate of lime, 64 grains to the wine pint. Of course where chloride of magnesium is abundantly present, the aspect of the chemistry of the case is modified. Berzelius, in accounting for the corrosion under sea water, has not included the chlorides among the agents concerned; but to our instance we cannot apply the views of Berzelius, for protochloride of iron sweating out of the pores of our pipe shows that the chlorine is implicated. Moreover, the Cranbourne meteorite, that known as Bruce's, sweated drops of chloride of iron, and showed on the outer surface symptoms of having suffered a considerable wasting by oxidation. The sweating and the rusting are, in the particular instance, connected by the fact that the drops of iron chloride solution, coming out from newly-polished artificial surfaces of the metal, rapidly corroded the surface, forming a crust of oxide of iron. In a letter received from England, it is stated that Professor Maskeleyne had expressed concern as to the future of the Bruce meteorite, on account of the decay to which it appeared subject. In the gaspipe and in the meteorite, two very different instances, we have the presence of iron protochloride accompanying, and apparently the disposing agent in effecting the passage of iron from the metallic state to the state of oxide.

It appears that the decay of cast-iron mains, due to salt in the soil, has been noticed elsewhere. Dr. John Smith, professor of chemistry in the Sydney University, has mentioned to the writer of this note a case occurring in India in which the mains, water-pipes it is believed, laid in swampy salt ground, perished so rapidly (in a few years in fact) that the engineer employed on the question proposed as the best remedy the use of steel mains laid in air, supported on piers. It was calculated that the additional strength of the proposed material over that of cast iron would allow of the use of steel pipes of so light a substance that their cost would not greatly exceed that of the quickly-perishing cast iron.

In the recent commission for inquiry concerning the City of Sydney Water Supply, this property of salt soil has not been overlooked—indeed the occurrence of salt ground has been regarded as a cogent reason against what might otherwise have been material to a practicable scheme for a high-level service.

That gas and water mains of cast-iron will, under ordinary circumstances, last in the ground for a great number of years is established by a wide experience, but that cases of an opposite nature occur is shown by the example brought forward. The writer has no personal knowledge concerning the average "life" of water and gas mains, but he observes in the little treatise on "Gasworks," by Hughes, that 1½ per cent. has been allowed for this deterioration in the case of gas mains. This would make the life say 66 years, or nearly two-thirds of a century, according to which computation renewal of the gas mains laid at the beginning of the present century, when gas lighting was coming into general use, would now be falling due. Recently, in Melbourne, for business purposes—that is to say, as the basis of a commercial transaction—a duration of 50 years was arbitrarily assumed and accepted as the "life" of local gas mains. Between the normal rate, if approximated in these quotations, and that which may take place in a salt soil, the difference is very great, and the subject is therefore one deserving of a full investigation. In laying down a service like that of the Yan Yean, we are, perhaps, too apt to regard the work as of an absolutely permanent character. Several years ago, the writer recommended, in reference to that particular service, that sample portions of the pipes should be set aside, properly labelled, so as to afford the means of future comparisons. He would now suggest the possibility of decay of cast-iron buried in the soil taking place at an accelerating, rather than an uniform rate—in a manner, for example, comparable to what takes place in the decay of timber. It might be well worth while to ascertain something concerning the earliest stages of molecular and chemical changes of cast-iron mains; when their conductivity for sound, for heat, and for electricity is first measurably affected; when the specific gravity is first sensibly altered; when the strength is first in any sensible degree impaired; and when the proportion of carbon, silicon, &c., to that of iron, is first measurably altered? Notwithstanding the inquiries of Hallet, under the auspices of the British Association, concerning the oxidation of iron, and admitting the value of the various researches by other workmen, if we are to judge from what appears in the books on this important subject, there is yet an ample field and much promise for those who will devote their time to a further opening of the inquiry. Anyone devoting effort to this particular subject of the decay of gas and water mains would, it is believed, reap results of great value and interest.

Apart from this larger work, there is a set of observations of another class, easy of performance, and which would always repay attention—that, namely, of ascertaining the nature of ground opened for the reception of mains, particularly as to saltness or freedom from salt. The writer is inclined to the belief that salt soils are far more common than is generally believed: the Plenty river, at its source in the ranges where the water first oozes out of the mossy ground, already shows evidence of chlorides in solution; the clay, *in situ*, at the Old Exhibition Reserve, in which the sample of gaspipe exhibited has decayed, retains 13 oz. of salt, at least, per cubic yard, although it is of a highly porous character, although situated at one of the highest levels in Melbourne, and doubtless after occupying its present position high above the sea for a long continuance of centuries, subject all the time to the influence of rain soaking into it, and having a greater or less power of dissolving and removing the salt. It is true that the subsoil partakes something of the nature of a barrier, the drainage escaping in many cases over it rather than through it, so that soluble saline matters travelling down into the subsoil may be thus cut off from the further transporting influence of drainage.

I will close these statements and suggestions with an incidental remark concerning the salting of land—namely, that it does not necessarily follow that the salt is in all cases derived *directly* from the sea, that the salt is that which was in the soil or clay or rock at the time when it formed a sea bottom, and was submerged in brine. The atmosphere may be ascertained to perform an important office in this respect intermediate between the sea and the land. There is reliable evidence that the atmosphere performs this function in some degree. To measure the extent to which the air acts as a distributor of sea-water constituents over the land would be a work replete with interest. It is a question which may prove itself closely related to the sciences of hygiene and agriculture, and even with geology.

Art. V.—*On η Argûs and Jupiter's Spectrum.* By A. Le Sueur, Esq.

[Read 14th March, 1870.]

I take this opportunity of mentioning that since the last meeting, the star η Argûs has been examined with the original apparatus, modified so as to admit of a larger dispersion.

With this new arrangement the red line keeps its place and character, the yellow is seen to be slightly less refrangible than *D*.